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EXAMINER

IM, JUNGHWA M

ART UNIT PAPER NUMBER

2811

DATE MAILED: 05/20/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

09/945,065

Applicant(s)

DERAA ET AL.

Examiner

Junghwa M. Im

Art Unit

2811

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 11 February 2003.
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-4 and 6-20 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-4 and 6-20 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
- Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- 11) ☐ The proposed drawing correction filed on _____ is: a) ☐ approved b) ☐ disapproved by the Examiner.
- If approved, corrected drawings are required in reply to this Office action.
- 12) ☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

- 13) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- * See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).
- a) ☐ The translation of the foreign language provisional application has been received.
- 15) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

- 1) ☐ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____
- 4) ☐ Interview Summary (PTO-413) Paper No(s). _____
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other: _____

DETAILED ACTION

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

Claims 1-4, 6-7, 9-14 and 16-20 are rejected under 35 U.S.C. 103(a) as being unpatentable over Taguwa (U.S. Pat. No. 6,404,058) in view of Thakur et al. (U.S. Pat. No. 6,262,485).

Regarding claim 1, Taguwa shows in Fig.3C an integrated circuit comprising:

a silicon substrate 201;

an insulating layer 204 formed on the silicon substrate wherein the insulating layer has an opening that extends from an upper surface of the insulating layer to an upper surface of the substrate as to expose the upper surface of the substrate;

a metal layer 209 formed in the opening wherein a first portion of the metal layer is formed on the exposed upper surface of the substrate wherein a second portion of the metal layer does not contact the substrate and remains unreacted; and

a metal silicide layer 210 on the upper surface of the second portion of the metal layer, and a metal nitride layer 211.

Taguwa shows a structure of the device substantially identical to the pending claim except a metal silicide layer formation in the exposed region of the substrate through the reaction of the metal layer with silicon. Thakur et al. show a device with a contact hole forming a

Art Unit: 2811

titanium silicide layer (530 in Fig. 5C) in a silicon substrate through depositing a titanium layer (col. 7, lines 6-43). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify the device of Taguwa with the teachings of Thakur et al. to decrease the ohmic resistance of a contact hole interconnection through forming a metal silicide region in a silicon substrate (col. 3, lines 62-64).

Taguwa also discloses the aspect of the adhesive property of titanium silicide throughout the specification, especially in col. 3, lines 9-51.

Regarding claim 2, Taguwa teaches in Fig. 3C the metal layer 209 comprises titanium.

Regarding claim 3, Taguwa teaches in Fig. 3C the metal nitride layer 211 comprises titanium nitride

Regarding claim 4, Taguwa teaches in Fig. 3C the metal silicide adhesion layer 210 comprises titanium silicide.

Regarding claim 6, Taguwa shows the metal silicide adhesion layer is approximately 50-150 angstrom thick (col. 5, line 49).

Regarding claim 7, Taguwa shows in Fig. 3C the opening is a contact opening.

Regarding claim 9, Taguwa shows in Fig. 3C the exposed upper surface of the substrate comprises a junction region 203.

Regarding claim 10, Taguwa shows in Fig. 3C an integrated circuit comprising a contact fill 212, 213 formed on an upper surface of the titanium nitride layer wherein the contact fill substantially fills the contact opening.

Regarding claim 11, Taguwa shows in Fig. 3C the contact fill 213 comprises titanium nitride.

Art Unit: 2811

Regarding claim 12, Taguwa shows the titanium nitride contact fill comprises TiCl_4 based titanium nitride (col. 5, lines 55-57).

Regarding claim 13, Thakur et al. show the contact fill comprises tungsten to form a low resistance interconnect (col. 4, lines 6-7).

Regarding claim 14, Taguwa discloses in Fig. 3C, a high aspect ratio contact structure formed over a junction region in a silicon substrate 201, comprising:

an insulating layer 204, wherein the insulating layer defines a contact opening, wherein the contact opening is formed over the junction region 203 of the substrate and exposes a portion of the substrate;

a titanium layer 209 formed in and adjacent the contact opening, wherein a first portion on the insulating layer and a second portion on the exposed substrate layer

a titanium silicide layer 210 formed on an upper surface of the first and the second portions of the titanium layer;

a titanium nitride contact fill 211 formed in and adjacent the opening, wherein the titanium nitride is formed on an upper surface of the titanium silicide layer, wherein the titanium nitride contact fill is adhered to the first portion of the titanium layer by the titanium silicide.

Taguwa shows a structure of the device substantially identical to the pending claim except a metal silicide layer formation in the exposed region of the substrate through the reaction of the metal layer with silicon. Thakur et al. show a device with a contact hole forming a titanium silicide layer (530 in Fig. 5C) in a silicon substrate through depositing a titanium layer (col. 7, lines 6-43). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify the device of Taguwa with the teachings of Thakur et al. to decrease the

Art Unit: 2811

ohmic resistance of a contact hole interconnection through forming a metal silicide region in a silicon substrate (col. 3, lines 62-64).

Taguwa also discloses the aspect of the adhesive property of titanium silicide throughout the specification, especially in col. 3, lines 9-51.

Regarding claim 16, Taguwa shows the titanium nitride contact fill comprises TiCl_4 based titanium nitride (col. 5, lines 55-57).

Regarding claim 17, Taguwa shows the insulating layer comprises BPSG (col. 2, lines 21-23).

Regarding claim 18, Taguwa shows the metal silicide adhesion layer is approximately 50-150 angstrom thick (col. 5, line 49).

Regarding claim 19, Thakur et al. teach to implant silicon within the titanium at the bottom of the contact hole (col. 7, lines 16-17). The silicide formed on annealing will therefore be interspersed in a titanium rich layer.

Regarding claim 20, Taguwa shows inherently the titanium silicide adhesion layer inherently comprises less chlorine than the titanium rich layer (col. 5, lines 2-51).

Claim Rejections - 35 USC § 103

Claims 8 and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Taguwa and Thakur et al. as applied to claims 1 and 14 above, and further in view of Dixit et al.

Regarding claims 8 and 15, Taguwa and Thakur et al. show most aspect of pending claim except the recited limitation on an aspect ratio of the contact opening.

However, Dixit et al show a device with a contact hole having an aspect ration of 10:1 (col. 3, line 64).

It would have been obvious to one of ordinary skill in the art at the time of the invention to modify an aspect ratio of the contact hole with the teaching of Dixit et al. since a contact hole with such an aspect ratio complies the current trend of the effort to minimize the size of the memory cell and improve the reliability of interconnection metals.

Response to Arguments

Applicant's arguments filed on February 11, 2003 have been fully considered but they are not persuasive. The rejection stands, modified only to accommodate the amendments made to the Claims by Applicant. New rejection are made in response to Applicant's claims.

On page 3 of the Amendment, Applicant states that "Taguwa does not address adhesion problems associated with a contact structure.... Titanium does not adhere well to the titanium nitride..." And Applicant goes on to explain that "...the present invention are directed toward improving the adhesion between the contact fill and the unreacted titanium on the insulation layer....". First, spanning from column 3, line 24 through line 52 of the specification, Taguwa discloses that a refractory metal silicide (an identical material to the instant invention) is used to absorb the metal stress which is caused by the separation between the titanium and titanium nitride layer, thus implying that a better adhesion is made through using titanium silicide. Second, the pending claims 1 and 14 do NOT recite that any adhesion between the titanium layer and the insulating layer. Rather, the pending claims recite the titanium silicide layer for adhesion

Art Unit: 2811

between the Ti layer and the TiN layer and Taguwa discloses this aspect in the portion of the specification (col.3 lines 24-52).

The teaching of Thakur is further introduced to show that titanium silicide formation on an exposed silicon layer through annealing the Ti layer on the silicon contact layer. A proper motivation is stated in the rejection above such as reduction of the ohmic resistance, or the contact resistance.

Conclusion

THIS ACTION IS MADE FINAL. Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire **THREE MONTHS** from the mailing date of this action. In the event a first reply is filed within **TWO MONTHS** of the mailing date of this final action and the advisory action is not mailed until after the end of the **THREE-MONTH** shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than **SIX MONTHS** from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Junghwa M. Im whose telephone number is (703) 305-3998. The examiner can normally be reached on **MON.-FRI. 8:30AM-5:00PM.**

Art Unit: 2811

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Tom Thomas can be reached on (703) 308-2772. The fax phone numbers for the organization where this application or proceeding is assigned are (703) 308-7722 for regular communications and (703) 308-7724 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 308-0956.

jmi
May 17, 2003


Sara Crane
Primary Examiner